Advanced Course in Psycholinguistics and Neurolinguistics
POSSIBLE AND IMPOSSIBLE LANGUAGES

Master on Linguistics
(Kepa Erdozia and Itziar Laka)

2011/01/26
INTRO:
The Brain and the Enigma of Impossible Languages
Neuroimaging Methods: (f)MRI
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Possible and Impossible Grammars
- Moro et al. 2001
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Is Broca the seat of Syntax?
The brain and the enigma of impossible languages


From Broca to Christopher
The brain and the enigma of impossible languages


**From Broca to Christopher**

- Phrenology: The study of the psychological characteristics of an individual based on the external shape of the cranium.
The brain and the enigma of impossible languages


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- **Monsieur Leborgne (TAN, †1861)**: ”Loss of speech, chronic softening, partial destruction of the Left Frontal Lobe of the brain” (Broca, 1861). The road to studying the biological basis of language had already been taken.
From Broca to Christopher

- XX Century: Fifties

Shannon: Information Theory, the grammars of human language could be interpreted using statistics. Chomsky working on automated translation. The structure of grammar is more complex than statistically based models. “The fact that all normal children acquire essentially comparable grammar of great complexity with remarkable rapidity suggests that human beings are somehow specially designed to do this” (Chomsky 1959).

Christopher was born in 1962. In most common intelligence tests, below average. Dissociation between language and other cognitive skills coincided with the knowledge of many languages and the ability to learn new ones.

Berber vs. Epun. Control subjects learned the Epun rules using general intelligence.
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Fundational aspects of human language

What is ”GRAMMAR”?
What is "GRAMMAR"?

- What are the parts that it is made of?
- How are they connected?
- When do they activate?
Grammar as a filter of combinations of primitive elements

**Primitive Elements (Lexicon)**

*Dante, one, Beatrice, day, saw, and, astonished, was*
Grammar as a filter of combinations of primitive elements

Primitive Elements (Lexicon)

*Dante, one, Beatrice, day, saw, and, astonished, was*

After the filters

*One day Dante saw Beatrice and was astonished*

or *One day Beatrice saw Dante and was astonished*

or *Dante saw Beatrice or Beatrice was astonished*

or even *Dante saw Beatrice one day and was astonished*
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*One day Dante saw Beatrice and was astonished*

or *One day Beatrice saw Dante and was astonished*

or *Dante saw Beatrice or Beatrice was astonished*

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However, there are impossible combinations, including: *Dante and astonished was one day Beatrice and Astonished Beatrice one.*
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Piattelli-Palmarini (1980)

- Instructive Grammars: The rules that describe the possible combinations.
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- **Instructive Grammars**: The rules that describe the possible combinations.
- **Selective Grammars**: The rules that eliminate the impossible combinations.
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- Instructive Grammars: The rules that describe the possible combinations.
- Selective Grammars: The rules that eliminate the impossible combinations.

By finding the impossible combinations, we will discover those general principles that help us understand how grammar works.
Combining its phoneme repertoire Standard American English could have 238 millions of billions of different words. What is the filter that reduces the huge number of words built out of a certain phoneme inventory?
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Filters

- syllable structure, vowel is required in English
- Morphemes cannot be combined freely.
- Syntax or combining words
ERRORS: Errors are natural in grammar.
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✓ Error has become a founding central factor in the theory and practice of modern research.
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IFG, STS, ...
(functional) Magnetic Resonance Imaging
(functional) Magnetic Resonance Imaging
A proton has a positive electric charge, and because it spins around itself, it produces a small magnetic field.

Miniature bar magnet with a north and south pole.
Spins align with magnetic field $B_0$

Outside scanner

Inside scanner
**T1:** Spins go back to up/down states.

---

**MRI image: T1**
T1: Spins go back to up/down states.

T1 is unique to every tissue: Time constant T1 is defined as the point where 63% of the magnetization M has recovered alignment with $B_0$. 

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T1 relaxation called longitudinal relaxation.
**MRI image: T1**

- **T1**: Spins go back to up/down states.
- **T1** is unique to every tissue:
  Time constant T1 is defined as the point where 63% of the magnetization $M$ has recovered alignment with $B_0$.
- **T1** relaxation called longitudinal relaxation.
- Returning to equilibrium.
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fMRI: BOLD Response
Supplying Energy

- Capillary networks supply glucose and oxygen.
- Haemoglobin carries glucose and oxygen to the neurons.
What does BOLD measure?

Changes in Magnetic properties of Haemoglobin

- More oxyhaemoglobin → increase signal
- More deoxyhaemoglobin → decrease signal

So... we are NOT measuring oxygen usage directly
Haemodynamic Response Function

1. Initial Dip.
2. Oversupply of oxygenated blood.
3. Decrease before return to baseline.
fMRI: Pros and Cons

Pros

- Great spatial resolution
fMRI: Pros and Cons

Pros

- Great spatial resolution
- Quantitative changes in specific brain areas
fMRI: Pros and Cons

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- Global Techniques (*neural networks*)
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**Pros**
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**Cons**
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- Limited space inside the magnet
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Possible and Impossible Grammars

Smith, Tsimpli, and Ouhalla 1993
- Polyglot savant Christopher.
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The researchers found that while Christopher learned Berber easily, he found it difficult to learn certain types of rules in Epun, particularly rules that violated **structure dependency**.
Moro et al. 2001

AIMS

- Isolate functional correlates of morphological and syntactic processing
- Neutralize the confounding effect of semantic component
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Participants

11 male (m.a. 26 y.o, range from 22 to 28)
Moro et al. 2001

AIMS

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TASK

Subjects were asked to detect anomalies in pseudowords:

- phonological anomalies
- morphosyntactic anomalies
- syntactic anomalies
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Quasi-Italian
- Nonwords in order to neutralize the to semantic component
- Inflections & Function Words (D, aux., P., pl., etc.) of Italian
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Syntactic Structure couldn’t be influenced by semantic interpretation
Visually presented 3 experimental conditions and 1 baseline PET experiment
Materials

✓ BASELINE
Il gulco gianeva le brale
Dm/sg Nm/sg V-AGRT/T3rd/sg Df/pl Nf/pl

X PHONOLOGICAL ANOMALIES
Il gulco giangzleva le brale

X MORPHOSYNTACTIC ANOMALIES
Il gulco gianigiata questo brale

X SYNTACTIC ANOMALIES
Gulco il gianeva le brale
Moro et al. 2001: Results

Behavioral Results
High accuracy in behavioral task

Functional Results
Common network of 3 experimental conditions (Baseline as reference):
- Pars Opercularis of Brocas area (Ba 44)
- Left inferior parietal lobule (Ba 40)
- The cuneus (Ba 18)
- Middle occipital gyrus (Ba 19 and 18)
- Bilateral superior parietal lobule (Ba 7)
- Bilateral precuneus (Ba 7)
- Bilateral fusiform gyrus (Ba 18/37)
- Cerebellum
- Cerebellar vermis
Moro et al. 2001: Results

Common neural network of 3 experimental conditions:

(A) (S+M+Ph)-Baseline masked with the individual simple main effect, $Z > 3.09$
Moro et al. 2001: Results

Morphosyntactic condition vs. Phonotactic condition

Significant activations:
- Circular Sulcus (BA 45)
- Right homologue of Broca’s area (BA 44, 45)
- Vermis

(C) (M-Ph) Z > 2.33
Moro et al. 2001: Results

Syntactic and Morphosyntactic processing detected in deep component of **Broca’s area** and in **right inferior frontal region**. Only for Syntactic processing: **Left caudate nucleus and insula**.
Moro et al. 2001: Discussion

**MAIN RESULTS**

- Syntactic and Morphosyntactic processing detected in deep component of Broca’s area and in Right Inferior Frontal region
- Only for Syntactic processing: Caudate nucleus and Insula
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**Moro et al. 2001: Discussion**

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- Only for Syntactic processing: Caudate nucleus and Insula

**CONCLUSIONS**
- Syntactic capacities are not implemented in a single area (Left and Right Broca’s areas, Basal Ganglia and the Cerebellum)
- Lack of a complete overlap between the neurological correlates for the syntactic and the morphosyntactic components of the language faculty (distinction made in theoretical linguistics)
Human language's syntactic rules are established on hierarchical syntactic notions (Chomsky, 1995). In human languages, there are no syntactic rules that are based on the number of words occurring in a given sentence.

**AIM**

Neuroanatomical differences between human language rules and no human language rules

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14 Italian monolinguals (7 male, m.a. 27.2 y.o., range 21 to 31)
fMRI Experiment

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GRAMMATICAL RULES (G)

Hierarchical phrase structure.

G-RULE: The article immediately follows the noun it refers to.
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**NONGRAMMATICAL RULES (NG)**

*Absolute position* of some elements within the linear sequence of words.

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**TASKS**

- RULE ACQUISITION (RA): During the stage of acquisition a syntactic rule had to be extracted.
- RULE USAGE (RU): During the stage of usage syntactic violations of acquired rules had to be detected.
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Tettamanti et al. 2002: Materials

QUASI-ITALIAN: 4 experimental conditions and 2 baselines

RULE ACQUISITION

a  RA-baseline: reading sentences following mother language syntax.
   Molte tille bilbavano il daffio
   Dt/p Nf/p V-T/agr-past/3rd-p Art.m/s Nm/s
**QUASI-ITALIAN:** 4 experimental conditions and 2 baselines

**RULE ACQUISITION**

a. RA-baseline: reading sentences following mother language syntax.
   - Molte tille bilbavano il daffio
   - Df/p Nf/p V-T/agr-past/3rd-p Art.m/s Nm/s

b. G-RA: reading sentences following new syntactic rule of a G nature.
   - Molte tille bilbavano daffio il
   - Df/p Nf/p V-T/agr-past/3rd-p Nm/s Art.m/s

   **G-RULE:** D immediately follows the noun it refers to
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   G-RULE: D immediately follows the noun it refers to

NG-RA: reading sentences following new syntactic rule of a NG nature.
Molte tille il bilbavano daffio
Df/p Nf/p Art.m/s V-T/agr-past/3rd-p Nm/s
NG-RULE: Art. immediately follows the second word in the sentence
Tettamanti et al. 2002: Materials

4 experimental conditions and 2 baselines

**RULE USAGE**

d RU-baseline: detecting violations of mother language syntax.

Tille molte bilbavano il daffio
Nf/p Df/p V-T/agr-past/3rd-p Art.m/s Nm/s

Syntactic Violation: N-D-V-Art-N → D-N-V-Art-N

NG-RU: detecting rule violations using the NG-rule knowledge acquired in [c].

Il molte tille bilbavano daffio
Art.m/s Df/p Nf/p V-T/agr-past/3rd-p Nm/s

Rule Violation: Art-D-N-V-N → D-N-Art-V-N
4 experimental conditions and 2 baselines

**RULE USAGE**

- **d RU-baseline:** detecting violations of mother language syntax.
  
  *Tille molte bilbavano il daffio*
  
  Nf/p Df/p V-T/agr-past/3rd-p Art.m/s Nm/s
  
  **Syntactic Violation:** N-D-V-Art-N → D-N-V-Art-N

- **e G-RU:** detecting violations using the G-rule knowledge acquired in [b].
  
  *Molte il tille bilbavano daffio*
  
  Df/p Art.m/s Nf/p V-T/agr-past/3rd-p Nm/s
  
  **Rule Violation:** D-Art-N-V-N → D-N-V-Art-N
### 4 experimental conditions and 2 baselines

#### RULE USAGE

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
<th>Example</th>
<th>Rule Violation</th>
<th>Corrected Rule</th>
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</tbody>
</table>
Tettamanti et al. 2002: Results

Overal main effects of rule acquisition compared with the baseline

**Grammatical Rules**
Opercular portion of Broca (BA 44)
Left Dorsal Premotor area (BA 6)
Left Angular Gyrus (BA 39)

**NonGrammatical Rules**
Right Middle Frontal Gyrus (BA 46)
Right Superior Parietal Lobule (BA 7)
Tettamanti et al. 2002: Results

**Significant temporal changes during rule acquisition**

**Behavioral Data:**
Same difficulty in G an NG rules acquisition

**fMRI Data:**
More activation during G rules than NG rules acquisition
Opercular Portion of Broca (BA 44)
Left Insula
Left Superior Frontal Gyrus (BA 8)
Right Ventral Inferior Frontal Gyrus (BA 47)
Right Inferior Parietal Lobule (BA 40)
Tettamanti et al. 2002: Results

**Effects of proficiency in rule usage**

**Behavioral Data:**

<table>
<thead>
<tr>
<th>Subject</th>
<th>G</th>
<th>Subject</th>
<th>NG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>High-proficiency group</strong></td>
<td></td>
</tr>
<tr>
<td>s13</td>
<td>98.4</td>
<td>s1</td>
<td>96.9</td>
</tr>
<tr>
<td>s4</td>
<td>96.9</td>
<td>s8</td>
<td>95.3</td>
</tr>
<tr>
<td>s2</td>
<td>95.3</td>
<td>s12</td>
<td>95.3</td>
</tr>
<tr>
<td>s10</td>
<td>95.3</td>
<td>s5</td>
<td>95.3</td>
</tr>
<tr>
<td>s9</td>
<td>92.2</td>
<td>s14</td>
<td>93.8</td>
</tr>
<tr>
<td>s7</td>
<td>92.2</td>
<td>s10</td>
<td>90.6</td>
</tr>
<tr>
<td>s3</td>
<td>90.6</td>
<td>s4</td>
<td>87.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Low-proficiency group</strong></td>
<td></td>
</tr>
<tr>
<td>s14</td>
<td>89.1</td>
<td>s3</td>
<td>84.4</td>
</tr>
<tr>
<td>s5</td>
<td>89.1</td>
<td>s11</td>
<td>82.8</td>
</tr>
<tr>
<td>s11</td>
<td>89.1</td>
<td>s9</td>
<td>78.1</td>
</tr>
<tr>
<td>s8</td>
<td>87.5</td>
<td>s7</td>
<td>76.6</td>
</tr>
<tr>
<td>s12</td>
<td>87.5</td>
<td>s6</td>
<td>73.4</td>
</tr>
<tr>
<td>s6</td>
<td>81.3</td>
<td>s13</td>
<td>73.4</td>
</tr>
<tr>
<td>s1</td>
<td>73.4</td>
<td>s2</td>
<td>70.3</td>
</tr>
</tbody>
</table>

*Note: For each subject (s1–s14), accuracy scores averaged over the four blocks are given for grammatical rule (G) and nongrammatical rule (NG) usage, respectively (expressed as percentage of correct answers).*
**Effects of proficiency in rule usage**

**Behavioral Data:**
No significant effects comparing G and NG

**fMRI Data:**
During G-rule usage
High-proficiency group activated significantly more
Broca’s Area (BA 44)
Left Ventral Premotor Area (BA 6)
Tettamanti et al. 2002: Conclusions

✓ Selective and robust participation of Broca’s area in the acquisition of novel Grammatical rules as opposed to Non-Grammatical rules.
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Perisilvian brain regions could be related to adults’ second language acquisition.
Tettamanti et al. 2002: Conclusions

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Direct comparison between two types of rules showed that human language grammatical rules specifically activated left hemispheric network, including Broca.
Musso et al. 2003

**AIM**

- To investigate the system underlying the acquisition of new linguistic competence of two parametrically different languages: Italian and Japanese.
AIM

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- To differentiate the rule learning based on UG and Non-UG systems.
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- To differentiate the rule learning based on UG and Non-UG systems.

**Participants**

- **Japanese Experiment**: 8 German natives learning real and unreal rules of Japanese (4 males; 22.6)
- **Italian Experiment**: 8 German natives learning real and unreal rules of Italian (4 males; 24.3)
Tasks

Syntactic correctness detection: Subjects read sentences in real and unreal language and then judged if they are correct according to the learned rules.
Musso et al. 2003

**Tasks**
Syntactic correctness detection: Subjects read sentences in real and unreal language and then judged if they are correct according to the learned rules.

**Methods**
During the fMRI in pauses between sessions (3min, 1min for each rule) subjects learned 3 real grammatical rules of Italian or Japanese and 3 artificial rules of an ”unreal” language using Italian or Japanese vocabulary.
Rule Learning

During the pauses between sessions one slide was presented describing each rule (for 30 s) with sentences to clarify the rule, followed by one slide for each rule (also for 30 s) several examples, some of which were grammatically incorrect. Here, the subject had to judge the grammatical correctness of the stimuli.
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Procedure

fMRI experiment lasted 44 min, 10 fMRI sessions.
Musso et al. 2003: Materials

3 rules of real and 3 rules of unreal Italian
Musso et al. 2003: Materials

3 rules of real and 3 rules of unreal Italian

**Real Italian: Hierarchical Relations**
- Null-subject parameter
- Passive formation
- Subordinate declarative
3 rules of real and 3 rules of unreal Italian

**Real Italian: Hierarchical Relations**
- Null-subject parameter
- Passive formation
- Subordinate declarative

**Unreal Italian: Lineal order of words**
- Negative construction: Put negative *no* after the third word in the sentence
- Interrogative: Invert the word order
- Article agreement: Indefinite article always agree with the last noun
### Italian Materials

#### Table 1 Sample sentences used in the Italian fMRI experiment

<table>
<thead>
<tr>
<th></th>
<th>Italian (real language learning task)</th>
<th>German (native language of subjects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null-subject parameter</td>
<td>Mangio la pera “Eat the pear”</td>
<td>Ich esse die Birne “I eat the pear”</td>
</tr>
<tr>
<td>Passive construction</td>
<td>La pera è mangiata da Paolo “The pear is eaten by Paolo”</td>
<td>Die Birne wird von Paul gegessen “The pear is by Paul eaten“</td>
</tr>
<tr>
<td>Subordinate construction</td>
<td>Pia dice che Paolo mangia la pera “Pia says that Paolo eats the pear”</td>
<td>Pia sagt, dass Paul die Birne isst “Pia says that Paolo the pear eats”</td>
</tr>
</tbody>
</table>

#### Unreal Italian

(artificial rules violating UG)

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<thead>
<tr>
<th></th>
<th>Italian (real language learning task)</th>
<th>German (native language of subjects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative construction</td>
<td>Paolo mangia la no pera “Paolo eats the no pear”</td>
<td></td>
</tr>
<tr>
<td>Interrogative construction</td>
<td>Pera la mangia Paolo “Pear the eats paolo”</td>
<td></td>
</tr>
<tr>
<td>Use of indefinite article</td>
<td>Una bambino mangia una pera “A (fem.) child (masc.) eats a (fem.) pear (fem.)”</td>
<td></td>
</tr>
</tbody>
</table>
Musso et al. 2003: Materials

3 rules of real and 3 rules of unreal Japanese
Musso et al. 2003: Materials

3 rules of real and 3 rules of unreal Japanese

Real Japanese: Hierarchical Relations

- Main clause word order. Jap $\rightarrow$ SOV; Ger $\rightarrow$ SVO
- Passive formation. Jap $\rightarrow$ -reru; Ger $\rightarrow$ ge-
- Subordinate declarative. Jap $\rightarrow$ S[SVO]V; Ger $\rightarrow$ SV[SOV]
Musso et al. 2003: Materials

3 rules of real and 3 rules of unreal Japanese

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- Main clause word order. Jap→SOV; Ger→SVO
- Passive formation. Jap→-reru; Ger→ge-
- Subordinate declarative. Jap→S[SVO]V; Ger→SV[SOV]

**Unreal Italian: Lineal order of words**
- Negative construction: Put negative *nai* after the third word in the sentence
- Interrogative: Invert the word order
- Past tense construction: Put *-ta* after on the second word counting from right to left.
**Musso et al. 2003: Materials**

### JAPANESE MATERIALS

**Table 2** Sample sentences used in the Japanese fMRI experiment

<table>
<thead>
<tr>
<th></th>
<th>Japanese (real language learning task)</th>
<th>German (native language of subjects)</th>
</tr>
</thead>
</table>
| Main clause construction | Paul wa nashi o taberu  
“Paul pear eat” | Paul ißt die Birne  
“Paul eats the pear“ |
| Passive construction | Nashi wa Paul ni taberareru  
“Pear Paul eat-passive suffix” | Die Birne wird von Paul gegessen  
“The pear is by Paul eaten“ |
| Subordinate construction | Pia wa Paul ga nashi o taberu to iu  
“Pia Paul pear eat that says” | Pia sagt, dass Paul die Birne isst  
“Pia says that Paolo the pear eats“ |

**Unreal Japanese (artificial rules violating UG)**

<table>
<thead>
<tr>
<th></th>
<th>Japanese</th>
<th></th>
</tr>
</thead>
</table>
| Negative construction | Paul wa nashi nai o taberu  
Paul pear eat no | |
| Interrogative construction | Taberu o nashi wa Paul  
Pear eat Paul | |
| Past-tense construction | Paul wa nashi o-ta taberu  
Pear eat-Past suffix | |
Musso et al. 2003: Results

**Behavioral Results**

**Italian**
- Performance (% correct) vs. Sessions
- Real grammars learning tasks were faster than unreal in Italian ($P < .0001$) and in Japanese ($P < .03$).

**Japanese**
- No differences in acquisition of real/unreal Italian and Japanese.

---

Master on Linguistics (Kepa Erdozia and Itziar Laka)
Advanced Course in Psycholinguistics and Neurolinguistics
Musso et al. 2003: fMRI Results

Interac: performance and type of rule (real vs. unreal It)

Changes in BOLD signal in the Left Inferior Frontal Gyrus
Common patterns of activation of real and unreal Italian

Right Inferior Frontal Gyrus
Musso et al. 2003: fMRI Results

Interaction: performance and tye pof rule in Jap

Changes in BOLD signal in the Left Inferior Frontal Gyrus
Musso et al. 2003: fMRI Results

Conjunction of analysis real-unreal learning experiment
(Jap)

Changes in BOLD signal in the Left Inferior Frontal Gyrus
Musso et al. 2003: Conclusions

Conclusion

The results indicate that the Left Inferior Frontal Gyrus is centrally involved in the acquisition of new linguistic competence, but only when the new language is based on principles of UG.
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The results indicate that the Left Inferior Frontal Gyrus is centrally involved in the acquisition of new linguistic competence, but only when the new language is based on principles of UG.
Increase of activation over time in Broca’s area was specific for real language acquisition only, independent of the language type.

Main Result
Increase of activation over time in Broca’s area was specific for real language acquisition only, independent of the kind of language.
Is Broca the seat of Syntax?

Evidence from Aphasia

- Left Anterior Temporal Lobe is also important in syntactic processing

Kaan and Swaab 2002

Possible and Impossible Grammars
Is Broca the seat of Syntax?
Is Broca the seat of Syntax?

Evidence from Aphasia

- Left Anterior Temporal Lobe is also important in syntactic processing
- Broca’s aphasics do not completely lack knowledge of syntax.
Is Broca the seat of Syntax?

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The brain areas that are damaged in Broca’s aphasics need not to be the areas where syntactic knowledge is stored.
Isolating Syntax

In previous Literature

1. Complex vs Simple sentences
Isolating Syntax

In previous Literature

1. Complex vs Simple sentences
2. Sentences vs. Lists of Words
INTRO:
Possible and Impossible Grammars
Is Broca the seat of Syntax?

Isolating Syntax

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1. Complex vs Simple sentences
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3. Sentences vs. Jabberwocky
Isolating Syntax

In previous Literature

1. Complex vs Simple sentences
2. Sentences vs. Lists of Words
3. Sentences vs. Jabberwocky
4. Correct vs. Incorrect sentences
INTRO:
Possible and Impossible Grammars
Is Broca the seat of Syntax?

Complex vs. Simple Sentences

BROCA (BA 44, 45)
- Complex conditions involve additional syntactic operations
INTRO:
Possible and Impossible Grammars
Is Broca the seat of Syntax?

Complex vs. Simple Sentences

BROCA (BA 44, 45)
- Complex conditions involve additional syntactic operations
- Canonical Word Order Reconstructions vs. Working Memory Load

Fig. 2. Complex versus simple sentences. Centers of activation for reading or listening to complex versus simple sentences (black symbols); for making a same/different judgment for syntactically different sentences (red symbol); and for processing sentences with long versus short dependencies (white symbols). In this and following figures, the dotted circle includes activations in Broca’s area. Centers of activation are projected on the left lateral, left medial, right lateral, and right medial surface of the brain, using Talairach coordinates [56]. Centers of activation are considered lateral if the absolute value of the x-coordinate is larger than 12 mm, and medial for x equal to or smaller than 12 mm. When the x-value is 0 mm, the center of activation is projected on the left medial surface.
INTRO:
Possible and Impossible Grammars
Is Broca the seat of Syntax?

Sentences vs. Words

no Broca activation

- Very simple sentences were used.
- → Broca is not necessarily involved in syntactic operations
- but only comes into play when the processing load increases.

Temporal Lobe

- sometimes bilateral
- patients with morphosyntactic problems
- superior and middle temporal gyri (BA 22, 21)
INTRO: Possible and Impossible Grammars
Is Broca the seat of Syntax?

Jabberwocky and Syntactic Prose

examples

The mumphy folofel fonged the apole trecon.
The infuriated water grabbed the justified dream.

STS
Posterior Superior Temporal Sulcus
Anterior Superior Temporal Sulcus
Syntactic violations have consequences for the semantic interpretation. Detecting syntactic errors of Jabberwocky enlarge activity in left BA45.
Kaan and Swaab 2002

Conclusions 1

1. Is there a specific area for syntax?
   NO
Conclusions 1

1. Is there a specific area for syntax? 
   NO

2. Temporal Lobe 
   Anterior, middle and posterior parts of the Superior and Middle Temporal Gyri.
Conclusions 1

1. Is there a specific area for syntax? NO
2. Temporal Lobe
   Anterior, middle and posterior parts of the Superior and Middle Temporal Gyri.
3. Are areas unique for syntactic processing? NO
   Broca and Temporal Lobe’s areas has been activated in processing of syntactically unconnected words, lists of syllables, semantics, even during music perception.
Conclusions 2

- Syntactic processing involves multiple brain areas.
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Conclusions 2

- Syntactic processing involves multiple brain areas.
- None of these areas are unique for syntax.
- Brain modularity for language remains unclear.
- Middle and superior temporal lobes $\rightarrow$ lexical processing.
- Anterior temporal lobe $\rightarrow$ encoding information.
- Borca $\rightarrow$ storing non-integrated material.
- Right areas $\rightarrow$ Prosody, ambiguity, discourse processing, and error detection.
INTRO:
Possible and Impossible Grammars
Is Broca the seat of Syntax?

The End